What is claimed is:

1. A method of manufacturing a thin film magnetic head including first and second magnetic layers magnetically coupled to each other and having first and second magnetic poles which face each other with a gap layer in between near and in a recording-medium-facing surface to be faced with a recording medium, a thin film coil portion provided between the two magnetic layers, and an insulating layer for insulating the thin film coil portion from the two magnetic layers,

wherein at least one of a step of forming the first magnetic pole and a step of forming the second magnetic pole includes:

a step of forming a magnetic material layer;

a step of forming a mask precursor pattern on the magnetic material layer;

a first etching step of forming a first mask having a narrower width by etching a part of the mask precursor pattern by ion beam etching and, simultaneously, etching the magnetic material layer to a depth in an area other than an area where the first mask is formed; and

a second etching step of forming at least one of the first and second magnetic poles by selectively etching the magnetic material layer by reactive ion etching with the first mask.

2. A method of manufacturing a thin film magnetic head according to claim 1, wherein an irradiation angle of an ion beam is changed at least once during the first etching step.

3. A method of manufacturing a thin film magnetic head according to claim 2, wherein during the first etching step, an angle in the width direction between a direction orthogonal to an extending direction of the magnetic material layer and an irradiation direction of the ion beam is changed from a first angle to a second angle which is larger than the first angle.

4. A method of manufacturing a thin film magnetic head according to claim 3, wherein in the first etching step,

the first angle is set to an angle plus or minus 15 degrees of 45 degrees, and

the second angle is set to an angle plus or minus 15 degrees of 75 degrees.

5. A method of manufacturing a thin film magnetic head including first and second magnetic layers magnetically coupled to each other and having first and second magnetic poles which face each other with a gap layer in between near and in a recording-medium-facing surface to be faced with a recording medium, a thin film coil provided between the two magnetic layers, and an insulating layer for insulating the thin film coil from the two magnetic layers,

wherein at least one of a step of forming the first magnetic pole and a step of forming the second magnetic pole includes:

a step of forming a magnetic material layer;

a step of forming a mask precursor pattern on the magnetic material layer;

a first etching step of forming a first mask having a narrower width by etching a part of the mask precursor pattern by ion beam etching; and

a second etching step of forming at least one of the first and second magnetic poles by selectively etching the magnetic layer by reactive ion etching with the first mask.

6. A method of manufacturing a thin film magnetic head according to claim 5, wherein in the first etching step, an ion beam is irradiated from a direction at an angle plus or minus 15 degrees of 75 degrees in the width direction, the angle being defined as an angle between the direction of the ion beam and a direction orthogonal to an extending direction of the magnetic material layer.

7. A method of manufacturing a thin film magnetic head including first and second magnetic layers magnetically coupled to each other and having first and second magnetic poles which face each other with a gap layer in between near and in to a recording-medium-facing surface to be faced with a recording medium, the first and second magnetic poles defining a recording track width of the recording medium, a thin film coil provided between the two magnetic layers, and an insulating layer for

insulating the thin film coil from the two magnetic layers,

wherein at least one of a step of forming the first magnetic pole and a step of forming the second magnetic pole includes:

a step of forming a magnetic material layer;

a step of forming a mask precursor pattern on the magnetic material layer;

a first etching step of etching the magnetic material layer to a depth in an area other than an area where the mask precursor pattern is formed, the first etching step being performed with the mask precursor pattern as a mask by ion beam etching; and

a second etching step of forming at least one of the first and second magnetic poles by selectively etching the magnetic material layer by reactive ion etching with the mask precursor pattern as a mask.

8. A method of manufacturing a thin film magnetic head according to claim 7, wherein in the first etching step, an ion beam is irradiated from a direction at an angle plus or minus 15 degrees of 45 degrees in the width direction, the angle being defined as an angle between the direction of the ion beam and a direction orthogonal to an extending direction of the magnetic layer.

9. A method of manufacturing a thin film magnetic head according to claim 1, further comprising a step of polishing the surface of the magnetic material layer so as to planarize the surface thereof between the step of

forming the magnetic material layer and the step of forming the mask precursor pattern.

10. A method of manufacturing a thin film magnetic head according to claim 1, wherein a step of forming the mask precursor pattern includes:

a step of forming a mask precursor layer on the magnetic layer; and

a third etching step of forming the mask precursor pattern by selectively etching the mask precursor layer by reactive ion etching.

11. A method of manufacturing a thin film magnetic head according to claim 10, wherein in the third etching step, a second mask having a shape corresponding to a plane shape of the mask precursor pattern is used.

12. A method of manufacturing a thin film magnetic head according to claim 11, wherein a photoresist film pattern having a predetermined plane shape is formed on the mask precursor layer and is used as the second mask.

13. A method of manufacturing a thin film magnetic head according to claim 11, wherein a metal film pattern having a predetermined plane shape is formed on the mask precursor layer and is used as the second mask.

14. A method of manufacturing a thin film magnetic head according to

claim 13, wherein the metal film pattern is formed by selectively growing a plating film on the mask precursor layer.

15. A method of manufacturing a thin film magnetic head according to claim 13, wherein a metal layer is formed on the mask precursor layer and is selectively etched to thereby form the metal layer pattern.

16. A method of manufacturing a thin film magnetic head according to claim 13, wherein either nickel iron or nickel copper is used as a material of the metal film pattern.

17. A method of manufacturing a thin film magnetic head according to claim 13, wherein either ion nitride or cobalt iron is used as a material of the metal film pattern.

18. A method of manufacturing a thin film magnetic head according to claim 13, wherein nickel boron is used as a material of the metal film pattern.

19. A method of manufacturing a thin film magnetic head according to claim 13, wherein nickel phosphor is used as a material of the metal film pattern.

20. A method of manufacturing a thin film magnetic head according to

claim 11, wherein in the third etching step, the second mask is etched to be removed.

21. A method of manufacturing a thin film magnetic head according to claim 10, wherein the mask precursor layer is deposited by chemical vapor deposition.

22. A method of manufacturing a thin film magnetic head according to claim 21, wherein the mask precursor layer is deposited under a pressure of 100 Pa or lower.

23. A method of manufacturing a thin film magnetic head according to claim 1, wherein a predetermined inorganic material is used as a material of the first mask.

24. A method of manufacturing a thin film magnetic head according to claim 23, wherein a material containing aluminum oxide or aluminum nitride is used as the inorganic material.

25. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the case where the first magnetic pole extends in a direction apart from the recording-medium-facing surface and defines a recording track width of the recording medium, and the first magnetic layer includes a first magnetic layer portion the first magnetic pole and a

second magnetic layer portion which covers an area of the thin film coil and is magnetically coupled to the first magnetic layer portion,

the first mask is formed so that a plane shape thereof includes at least a portion corresponding to the first magnetic pole in the first magnetic layer portion.

26. A method of manufacturing a thin film magnetic head according to claim 25, wherein in the case where the first magnetic layer portion further includes an expanded portion which is magnetically coupled to the first magnetic pole on the side far from the recording medium facing surface and is wider than the first magnetic pole, a step in the width direction is formed in a position where the first magnetic pole and the expanded portion are coupled to each other, and a corner is formed at a part where a side face of the first magnetic pole and a step face of the expanded portion in the step cross each other,

the first mask is formed so that the plane shape thereof includes a part corresponding to a plane shape of the expanded portion, and an angle at a part corresponding to the corner of the first magnetic layer portion lies in a range from 90 degrees to 120 degrees.

27. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the third etching step, an etching process is performed in a gas atmosphere containing at least one of chlorine, boron trichloride, hydrogen chloride, carbon tetrafluoride, sulfur hexafluoride, and boron

tribromide.

28. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the third etching step, an etching process is performed at a temperature in a range from 50 degrees to 300 degrees.

29. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the second etching step, at least the first magnetic pole in the first magnetic layer is formed.

30. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the second etching step, at least the second magnetic pole in the second magnetic layer is formed.

31. A method of manufacturing a thin film magnetic head according to claim 29, wherein an area in the gap layer other than an area where the first magnetic pole is formed, is selectively removed by reactive ion etching.

32. A method of manufacturing a thin film magnetic head according to claim 29, wherein formation of the first magnetic pole in the first magnetic layer, selective removal of the area in the gap layer other than the area where the first magnetic pole is formed, and formation of the second magnetic pole in the second magnetic layer are continuously performed in a series of steps.

33. A method of manufacturing a thin film magnetic head according to claim 32, wherein the first magnetic pole in the first magnetic layer is formed with a first mask made of a predetermined inorganic material as a mask, and

the selective removal of the gap layer and formation of the second magnetic pole in the second magnetic layer are performed with at least one of the first mask and the first magnetic pole as a mask.

34. A method of manufacturing a thin film magnetic head according to claim 25, wherein in the step of forming the first magnetic layer,

the second magnetic layer portion is formed separately from the first magnetic layer portion by reactive ion etching.

35. A method of manufacturing a thin film magnetic head according to claim 34, wherein the second magnetic layer portion is formed so that the second magnetic layer portion is partially overlapped with a part of the first magnetic layer portion, and an end on the recording-medium-facing surface side of the second magnetic layer portion is positioned apart from the recording-medium-facing surface.

36. A method of manufacturing a thin film magnetic head according to claim 34, wherein in the case where the thin film coil portion has a first thin film coil layer pattern and the insulating layer has a first insulating layer portion which buries at least the first thin film coil layer pattern, the

method comprises:

a step of forming the first insulating layer portion so as to cover at least the first magnetic layer portion and the first thin film coil layer pattern; and

a step of forming a first planarized face by polishing a surface of the first insulating layer portion until at least the first magnetic layer portion is exposed.

37. A method of manufacturing a thin film magnetic head according to claim 36, wherein the second magnetic layer portion is formed on the first planarized face.

38. A method of manufacturing a thin film magnetic head according to claim 36, wherein in the case where the first magnetic layer includes a third magnetic layer portion between the first and second magnetic layer portions, the third magnetic portion magnetically coupling the first magnetic layer portion and the second magnetic layer portion

the third magnetic layer portion is patterned on the first planarized face by reactive ion etching.

39. A method of manufacturing a thin film magnetic head according to claim 38, wherein the third magnetic layer portion is formed so that the third magnetic layer portion is overlapped with both a part of the first magnetic layer portion and a part of the second magnetic layer portion and

an end on the recording-medium-facing surface side of the third magnetic layer portion is positioned apart from the recording-medium-facing surface.

40. A method of manufacturing a thin film magnetic head according to claim 38, wherein in the case where the thin film coil portion further has a second thin film coil layer pattern disposed in a layer different from the first thin film coil layer pattern, and the insulating layer further has a second insulating layer portion for burying at least the second thin film coil layer pattern, the method comprises:

a step of forming the second thin film coil layer pattern on the first planarized face and forming a first connection pattern serving as a part of the thin film coil portion integrally with the second thin film coil layer pattern at an end;

a step of forming the third magnetic layer portion and forming a second connection pattern on the first connection pattern, the second connection pattern serving as a part of the thin film coil portion;

a step of forming the second insulating layer portion so as to cover at least the third magnetic layer portion, the second thin film coil layer pattern, and the second connection pattern;

a step of forming a second planarized face by polishing a surface of the second insulating layer portion until at least both of the third insulating layer portion and the second connection pattern are exposed; and

a step of forming a conductive layer pattern so as to be electrically

connected to an exposed face of the second connection pattern on the second planarized face.

41. A method of manufacturing a thin film magnetic head according to claim 40,

wherein the second magnetic layer portion is further formed on the second planarized face.

42. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the case where a magnetic transducing function film extending in a direction apart from the recording-medium-facing surface, and a third magnetic layer for magnetically shielding the magnetic transducing function film, the third magnetic layer is formed through an etching process using reactive ion etching.

43. A method of manufacturing a thin film magnetic head according to claim 1, wherein the magnetic material layer is deposited by sputtering with a predetermined magnetic material.

44. A method of manufacturing a thin film magnetic head according to claim 43, wherein a material containing iron nitride is used as the predetermined magnetic material.

45. A method of manufacturing a thin film magnetic head according to

claim 43, wherein an amorphous alloy is used as the predetermined magnetic material.

46. A method of manufacturing a thin film magnetic head according to claim 45, wherein a material containing iron cobalt zirconium oxide alloy is used as the amorphous alloy.

47. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the second etching step, an etching process is performed in a gas atmosphere containing at least one of chlorine, boron trichloride, and hydrogen chloride.

48. A method of manufacturing a thin film magnetic head according to claim 1, wherein in the second etching step, an etching process is performed at a temperature in a range from 50 degrees to 300 degrees.